The Experiments: Part II

The following projects are provided by the National Energy Education Development Project, NEED. They are recommended for use in **Grades 7 - 12**. These projects are from NEED's "Science of Energy" booklet and are reprinted with permission. They have been modified for use in this guidebook.

Exploring Thermal Energy

The following experiments investigate *exothermic reactions* (reactions that produce heat) and *endothermic reactions* (reactions that use heat).

Project #1: Endothermic Reactions

MATERIALS:

- 1 Bottle of Vinegar
- 1 Container of Baking Soda
- 4 Empty Plastic Sandwich Bags
- 1 Thermometer
- 1 Spoon

PREPARATION:

- Study the sample script to learn the experiment.
- Examine the equipment.
- Practice your presentation.

PROCEDURE:

- Explain that you are going to mix two chemicals together to make a third chemical. The reaction is an endothermic reaction – it requires energy in the form of heat to make the third chemical from the first two.
- Pour about an ounce of vinegar into an empty plastic sandwich bag.
- Feel the vinegar in the bag to note the temperature. Measure the exact temperature using the thermometer.
- Record the temperature of the vinegar. Leave the thermometer in the bag.
- Carefully pour about a teaspoon of baking soda into the bag with the vinegar. Be careful – the reaction will foam to the top of the bag.
- Watch the temperature on the thermometer drop. It should drop about 5 degrees Centigrade in 30 seconds.
- Record the time and temperature and remove the thermometer from bag.
- Feel the bag again to note the temperature.
- Carefully zip bag and put it aside.

ORAL PRESENTATION

This script is just a sample. You don't need to say it word for word. The important thing is to get the major concepts and facts across to your audience.

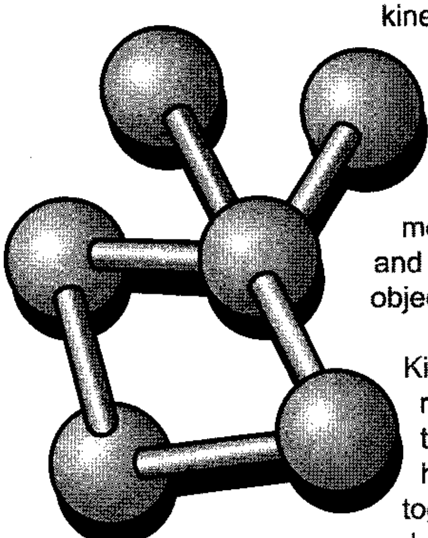
During this experiment, you'll be learning about chemical reactions. Chemical reactions occur when you mix two [or more] chemical compounds together to form other compounds. All chemical reactions involve heat. Some give off heat and some use heat.

An endothermic reaction uses heat. *Endo* means *in* and *thermal* means *heat*. Endothermic – the heat goes in. Since the easiest way to measure heat is by its temperature, we'll use a thermometer to show the changes in heat.

This experiment is an endothermic reaction – it uses heat. I'm going to mix vinegar and baking soda together to make another chemical. First, I'll add the vinegar and check the temperature of it. [Pour about an ounce of vinegar into an empty plastic bag. Hold the bag at the top and tilt it so that all the vinegar is in one corner. Take the temperature of the vinegar. It should be about room temperature. Let everyone touch the bag.] It is _____ degrees.

Everyone touch the bag so you'll know what the temperature feels like. Now I'm going to add the baking soda. You'll be able to see a reaction taking place. [Leave the thermometer in the bag. Pour in about a teaspoonful of baking soda. Be careful; the reaction will foam very high.] Now, watch the temperature on the thermometer. [The temperature should drop four to five degrees Centigrade in 30 seconds. Let everyone touch the bag again.] The temperature has dropped about four to five degrees. Now touch the bag and tell me how it feels. Do you feel the difference?

It feels colder because the reaction we just saw uses energy. [Take thermometer out of bag. Zip up bag and put to the side with the vinegar and baking soda.] Heat is a form of kinetic energy – the vibration of molecules. The more heat energy, the more the molecules vibrate and the hotter the object feels.



Kinetic energy is required to break the bonds that hold molecules together and is released when bonds are formed. [Show the formulas for endothermic reactions on page 17] The top equation shows the reaction of vinegar and baking soda. The reaction takes more energy to break the bonds than to form the new bonds. The reaction takes the energy it needs from the surrounding environment, which is why the bag feels colder. The second equation is photosynthesis – another endothermic reaction. Sunlight – or radiant energy – is needed to combine water and carbon dioxide to form more complex chemical compounds.

Project #2: Exothermic Reactions

MATERIALS:

- 4 Handwarmers
- 1 Sealed Bag of Iron Oxide
- 1 Container of Calcium Chloride
- 2 Empty Plastic Bags
- Scissors
- 2 Ounces of Water

PREPARATIONS:

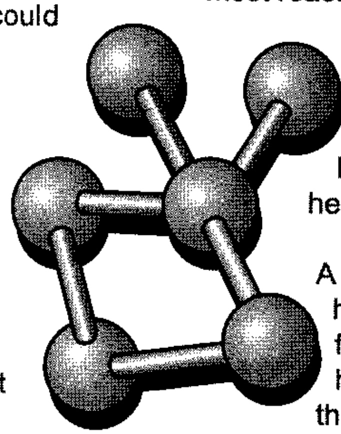
- Study the sample script to learn the experiment.
- Examine the equipment.
- Practice your presentation.
- The sealed bag of iron oxide contains old filings from the handwarmers. This is called the old packet. A few minutes before your first presentation, cut open a new packet and pour it into an empty plastic bag. Keep the bag open so that oxygen in the air can react with the black powder. This is called the new packet.

PROCEDURE: HANDWARMERS

- Explain that you are going to let oxygen come into contact with pieces of iron to produce a third chemical – iron oxide. The reaction is an exothermic reaction – it produces energy in the form of heat. Most reactions are exothermic.
- Show the package that held the iron filings.
- Feel the new packet to note the temperature.

- Seal the new packet to prevent oxygen from entering the bag.
- Let students feel the old packet and note the temperature.
- After performing the second part of the demonstration – driveway ice – let students feel the new packet that you sealed, pointing out the temperature drop after the bag was sealed and no oxygen could enter to keep the reaction going.

PROCEDURE: DRIVEWAY ICE



- Explain that calcium chloride is used to melt ice on sidewalks and driveways. When calcium chloride comes into contact with water, a reaction takes place that produces heat.
- Pour two ounces of water into a plastic bag. Record the temperature using the thermometer.
- Pour a teaspoon of calcium chloride into the water.
- Record the temperature.
- Seal the bag and put it aside.

ORAL PRESENTATION:

Most reactions don't take in heat like vinegar and baking soda. Most chemical reactions give off heat – they're exothermic. *Exo* means *out* and *thermal* means *heat*. Exothermic – the heat goes out. Let's watch a reaction that gives off heat.

A few minutes ago I opened this handwarmer. It was filled with iron filings. [Show audience the package the hand warmer came in.] Why do you think it was sealed in plastic? [Get answers from audience.] The plastic keeps air from reaching the iron. I put the iron filings into this plastic bag and left it open so that oxygen could get to it. [Hold up new packet.] The oxygen

ENDOTHERMIC REACTIONS

VINEGAR AND BAKING SODA

Vinegar	+	Baking Soda	+	Heat	→	Water	+	Carbon Dioxide	+	Sodium Acetate
CH_3COOH	+	$NaCO_3$	+	Heat	→	H_2O	+	CO_2	+	$NaC_2H_3O_2$

PHOTOSYNTHESIS

Water	+	Carbon Dioxide	+	Radiant Energy	→	Glucose	+	Oxygen
$6H_2O$	+	$6CO_2$	+	Radiant Energy	→	$C_6H_{12}O_6$	+	$6O_2$

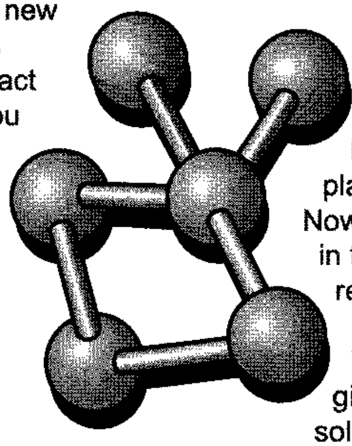
EXOTHERMIC REACTION

IRON FILINGS

Iron	+	Oxygen	→	Iron Oxide (Rust)	+	Heat Energy
4Fe	+	$3O_2$	→	$2Fe_2O_3$	+	Heat Energy

in the air is reacting with the iron to form a new chemical, iron oxide, or rust.

Feel this packet. [Let everyone feel new packet. It should feel warm.] It feels warm. When oxygen comes in contact with iron, it makes rust and heat. You can see that most of the iron filings are still black. [Show the formulas for exothermic reactions on page 17] They will slowly turn to rust as long as we let oxygen reach them. Now, I'm going to seal the bag. No oxygen will be able to get to the iron filings. The reaction should slow down and stop. At the end of the presentation, we'll feel the bag again to see if the temperature has changed.



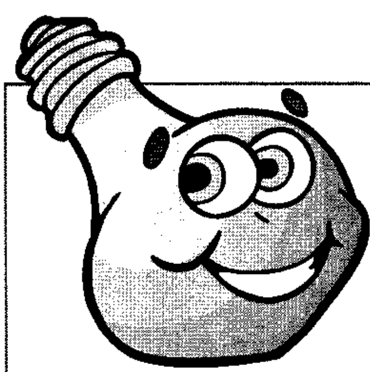
Here is a packet of filings that has been open for several weeks. [Hold up old packet. Let everyone feel it.] As you can see, all the iron has turned to rust. No more heat is being produced. Why do you think the handwarmer has a lot of iron filings instead of one chunk of iron? [Get answers from audience.] Because more iron can come in contact with oxygen when it is in small pieces.

Let me demonstrate another reaction. This container contains calcium chloride - it is used to melt ice on sidewalks and driveways. When calcium chloride comes in contact with water, a reaction occurs and heat is produced.

Let's put two ounces of water into this plastic bag and record the temperature. Now, let's put a teaspoon of calcium chloride in the water. Since this is an exothermic reaction, will the temperature of the water increase or decrease? [Get answers.] That's right. Since exothermic reactions give off heat, the temperature of the solution should increase. [Record temperature.] As you can see, the temperature of the water is now _____.

Feel the bag of iron filings that I sealed a few minutes ago. [Pass the new packet around.] The iron filings are cooler, aren't they? Sealing the bag kept oxygen from coming in contact with the iron. The reaction has stopped. No more heat is being produced.

Do you have any questions?



Here's an IDEA...

Save your old science fair project and expand on it each year.

Science Fair Project #3: The Apple Battery

This project examines electricity and transforming chemical energy into electricity.

MATERIALS:

- 1 Large Zinc Nail
- 1 Small Zinc Nail
- 1 Meter
- 1 Display Sheet (page 21)
- 1 Thick Copper Wire
- 1 Thin Copper Wire
- 1 Set of Tin Wire Alligator Clips
- 1 Apple

PREPARATION:

- Study the sample script to learn the experiment.
- Examine the equipment.
- Practice your presentation.
- Attach clips to the leads of the meter. Place the meter so the audience can see its face. If the needle of the meter seems to stick, gently tap the face of the meter.

PROCEDURE:

- Explain that you will be using the chemical energy in an apple to make electricity, as described in the script.
- Insert large zinc nail and thick copper wire into the apple about one centimeter, making sure they don't touch each other. Attach the clip with the green label to the zinc nail, the other clip to the copper wire. Point out the meter reading.
- Using the Display Sheet, explain to the audience how the acid in the apple reacts with metals to free electrons and produce an electric current.
- Push the nail and wire farther into the apple and point out the meter reading.
- Pull the copper wire out part way, then reverse the arrangement, noting the meter.
- Push the nail and wire into the apple so that they are touching. Point out that there is no current and explain why.
- Insert the thin copper wire and compare the meter readings of the copper wires with the nail.
- Attach the meter to the two copper wires and explain why there is no current.
- Insert the tin wire into the apple, along with the copper and zinc, making sure none of them touch. Explore the different combinations of metals.

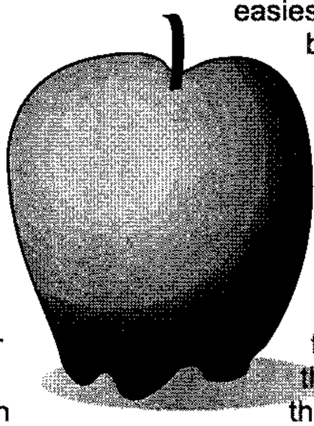
ORAL PRESENTATION:

This script is just a sample. You don't need to say it word for word. The important thing is to get the major concepts and facts across to your audience.

Welcome to my power plant. I'm going to make electricity for you today. Most of the electricity we use today is made with turbine generators, but I'm going to use an apple and some pieces of different metals. I'm going to use the chemical energy in the apple to make electricity without a turbine.

Chemicals are everywhere. Take this apple, for example. [Hold up apple.] I'm going to use the malic acid in this apple to show how a battery works.

Here I have a zinc nail and a piece of copper wire. I'm going to push them into the apple. [Insert the large nail and thick copper wire about one centimeter into the apple, making sure they don't touch. Attach the clip with the green label to the zinc nail and the other clip to the wire.] Now I'm going to attach them to the meter, which detects electric current. As you can see looking at the meter, I've produced an electric current. The question is, why?



When I put the zinc and copper into the apple, both metals react with the acid. The acid frees many electrons from both metals. But they don't react exactly the same way. The metals lose electrons in different amounts. Let's say, to keep it simple, that for every two electrons the copper loses, the zinc loses four. This creates an imbalance. The copper becomes an electron donor. The zinc becomes an electron acceptor. [Show diagram on page 21.]

Since the zinc is losing more electrons than the copper, the zinc takes electrons from the copper to equalize the electric charge. So, electrons from the copper wire flow through the wires and the meter to the zinc nail. Look at the direction the needle on the meter is pointing. It shows that electrons are flowing from the copper to the zinc. This is the way all batteries work. There are chemicals in batteries and the electrons flow from one metal to another, converting chemical energy into electrical energy.

What will happen if I push the zinc and copper all the way into the apple? [Push both in about four centimeters, making sure they don't touch.] Look at the meter. There is more electric current, because there are more electrons free to move. Electricity is just moving electrons.

What will happen if only one metal is pushed in all the way? [Pull copper most of the way out.] Let's see. The current drops, doesn't it? There isn't as much copper to give up electrons. Let's try the opposite way, pushing in the copper and pulling out the zinc. Same result, right? Even if there's a lot of copper to give up electrons, there isn't a lot of current because there isn't a lot of zinc to accept the electrons.

This time I'm going to push both metals into the apple so they're touching each other. What do you think will happen? [Push copper wire and nail in so the ends touch inside the apple.]

No current is flowing through the meter. Does that mean there are no moving electrons? No, it just means the electrons are flowing straight from one metal to the other. Electrons always take the easiest path. This is called a short circuit, because the electricity is taking the shortest path.

Let's try something else. I'm going to put this thin copper wire into the apple, too, so we can compare the current. Which wire do you think will produce more current? [Put both wires and nail into apple about four centimeters so they aren't touching each other. Measure the current using the thick wire, then the thin wire.] First, let's measure the current of the thick copper wire. Now let's measure the thin wire. The thick wire produces more current, because it has more surface to come in contact with the acid.

What do you think will happen if I attach the two copper wires to the meter? [Attach copper wires to the meter.] Let's try it and see. There shouldn't be any current, should there? There is no metal producing electrons. Let's attach both zinc nails to the meter and see what happens. [Attach both zinc nails to the meter.] There is no current produced in this case either. There is no metal to accept the electrons that are freed from the zinc. There are no moving electrons.

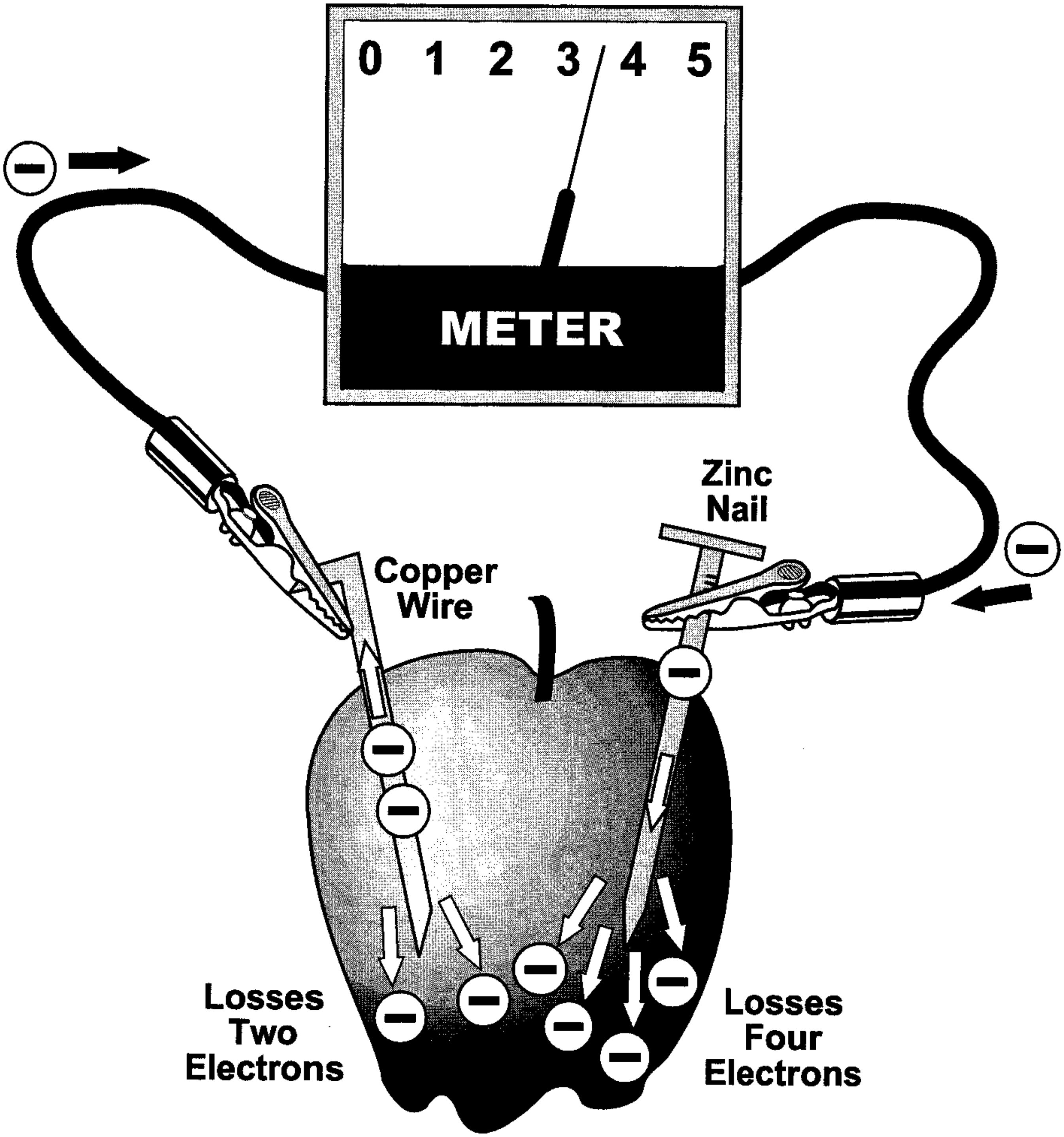
Now let's try a new metal – tin. Let's place all three metals into the apple to see if tin will be an electron donor or acceptor. [Insert large zinc nail, thick copper wire, and tin wire into the apple, making sure they don't touch.] When I attach the alligator clip with the green label to the tin and the other clip to the copper, you can see that tin is an electron acceptor.

When I switch the clip from the copper wire to the zinc nail, watch what happens. The needle moves the other way. That's because the tin has now become the donor. The combination of metals determines which metal will be the electron donor.

We have explored several ways an apple battery can convert chemical energy into electricity.

Do you have any questions?

Electrochemical Cell



Science Fair Project #4: Magnets

This project will explore *electricity* and *magnetism.* It will also investigate transforming mechanical energy into electricity.

MATERIALS:

- 1 Large Magnet
- 1 Small Magnet
- 1 Meter
- 1 Small Coil with Many Turns
- 1 Large Coil with Few Turns
- The Illustration on Page 23

PREPARATION:

- Study the sample script to learn the experiment.
- Examine the equipment.
- Practice your presentation.
- Attach clips to the leads of the meter. Place the meter so the audience can see its face. If the needle of the meter seems to stick, gently tap the face of the meter.

PROCEDURE:

- Using the illustration on page 23, briefly explain how power plants generate electricity.
- Connect the clips from the meter to the leads on the small coil with many turns. It doesn't matter which way you connect them.
- Slide the flat side of the large magnet back and forth over the coil several times, NOT TOUCHING THE COIL. Note the movement of the needle from side to side. Vary the speed with which you move the magnet and note the meter.
- Rest the magnet on top of the coil and note that no current is produced.
- Place the magnet on the table. Place the coil on it, then quickly pull it away. Note the meter.
- Rest the coil on the magnet. Move the magnet and coil together. Note that no current is produced.
- Demonstrate with both magnets to compare the strength of the magnet.
- Demonstrate with both coils, making sure to point out the difference in the number of turns of the wire.

ORAL PRESENTATION:

This script is just a sample. You don't need to say it word for word. The important thing is to get the major concepts and facts across to your audience.

There are lots of different ways to make electricity, but I'm here to show you how the pros do it. More than 160 years ago, Michael Faraday discovered that if you move a magnet through a coil of copper wire, you produce an electric current in the wire. All of our major power plants produce electricity this way. [Explain the illustration of page 23.]

Power plants use energy to spin a huge turbine. The turbine rotates a magnet in a coil of copper wire to produce electricity. Lots of different kinds of energy are used to spin the turbines. In most power plants, coal is burned to make steam. The steam is used to spin the turbines. Windmills use the mechanical energy in the wind to spin the turbines.

Today, I'm going to use my mechanical energy to make electricity. Here I have a coil of copper wire I am attaching to a meter that measures electric current. And here I have a magnet. [Attach the small coil with many turns to the meter. Place the large, flat side of the magnet over the top of the coil – near BUT NOT TOUCHING. Move the magnet back and forth over the coil several times.]

When I use my mechanical energy to move the magnet over the coil, I make electricity. Watch the meter – notice the needle jump from side to side. That means the current is alternating from one direction to the other. I'm producing an alternating current. It's called an AC current and it's the kind of electricity we use in our homes. The electricity you get from a battery is direct – or DC – current. That means it always flows in one direction. Batteries produce DC current.

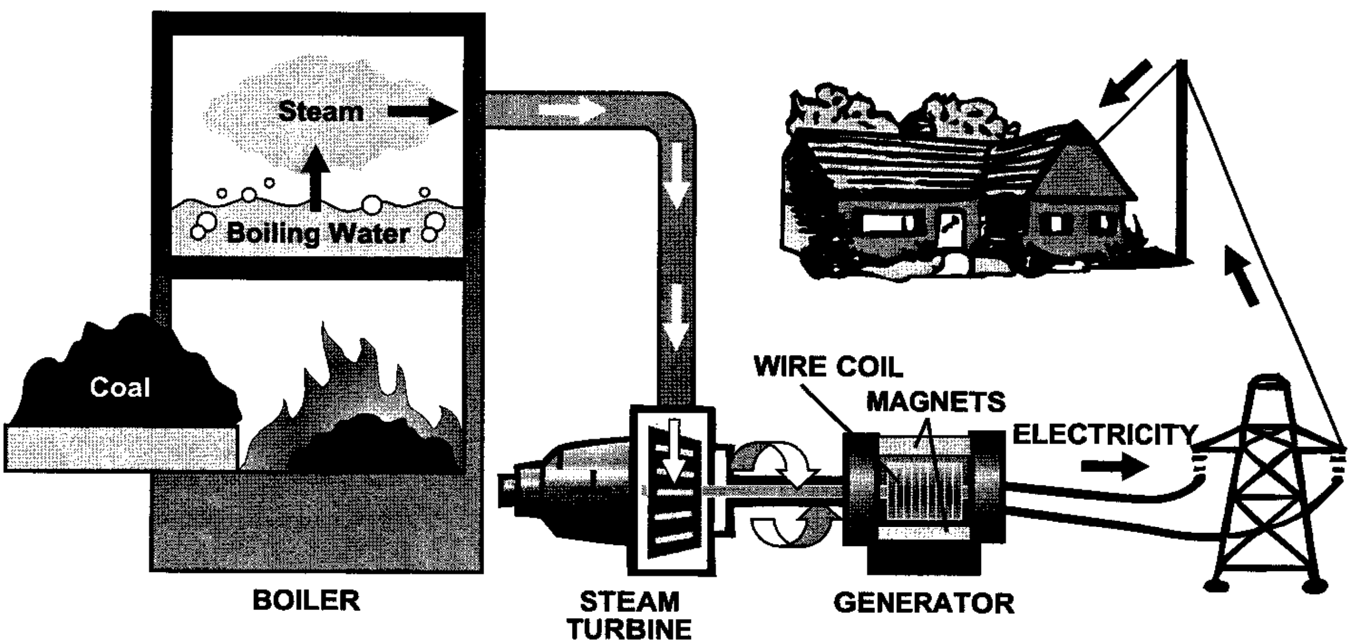
If I just rest the magnet on top of the coil, no electricity is produced. No mechanical energy is being used to make the electrical energy.

What do you think will happen if I put the magnet on the table and move the coil? Let's try it and see. [Place the coil over the magnet, then move it away several times.] It produces electricity. It doesn't matter whether we move the magnet or the coil, as long as one of them moves and the other doesn't. If I move both the magnet and the coil in the same direction at the same speed, no electricity will be produced. Watch. [Place the coil on top of the magnet and move them together.]

Let's see what we can do that affects the amount of electricity we produce. First, let's try speed. Do you think I can produce more electricity if I move the magnet quickly? First, I'll move the magnet slowly – let's see what the meter reads. [Slowly move the magnet over the coil several times, noting the reading on the meter.]

Now, let's try moving the magnet faster. [Move magnet quickly.] I produce more electricity when I move the magnet faster, don't I? That's because I'm putting more mechanical energy into the magnet when I move it quickly.

Can you think of anything else that might affect the amount of electricity produced? How about the strength of the magnet? Here I have a smaller magnet. Let's see what happens when I move



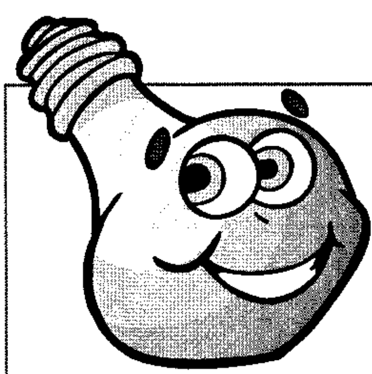
Above: *This illustration show how coal is burned to make electricity.*

both magnets at the same speed. [Demonstrate with both magnets several times, trying to keep your speed the same.] The larger one produces more electricity. So a stronger magnet produces more electricity.

There's another thing that can affect the amount of electricity produced – the number of turns in the coil. I have two coils here, one with many more turns than the other. [Let the audience examine both coils.] Let's try the experiment again. [Demonstrate using both coils.] The coil with more turns produces more electricity, even though it's smaller.

Today, we've learned that we can make electrical energy using mechanical energy to move a magnet across a coil of copper wire. We've also learned that the strength of the magnet, the speed of the magnet, and the number of turns in the coil all affect the amount of electricity produced.

Do you have any questions?



Here's an IDEA...

Ask adults for information about your project, but DO THE WORK YOURSELF!